# Integrated Product Design Simulation

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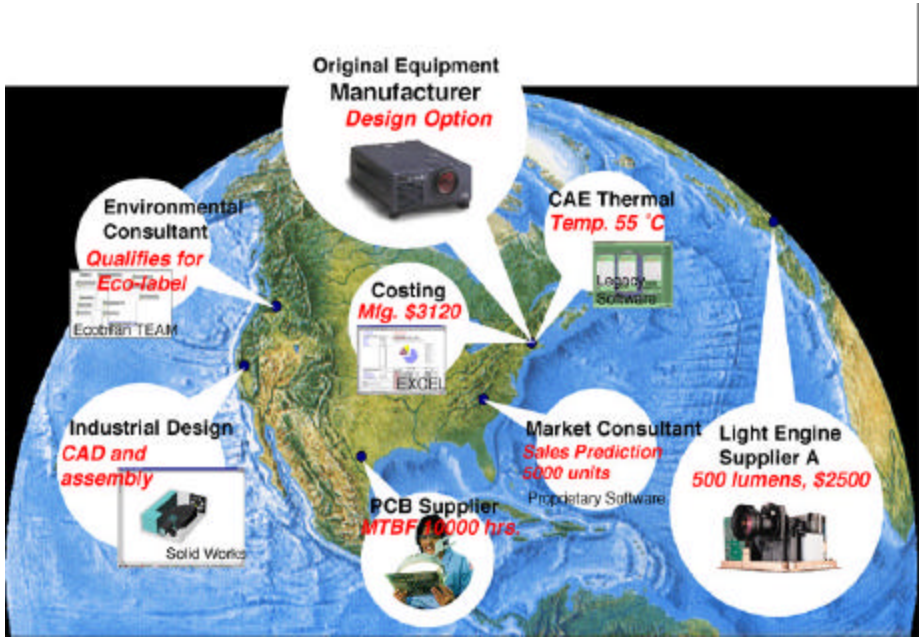
DOME (distributed object-based modeling environment)

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**Abstract**

**Subject Terms**

| | |
|---|---|
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**Number of Pages**
31

# Integrated Product Design Simulation

## Outline

Design context

Need

Concept

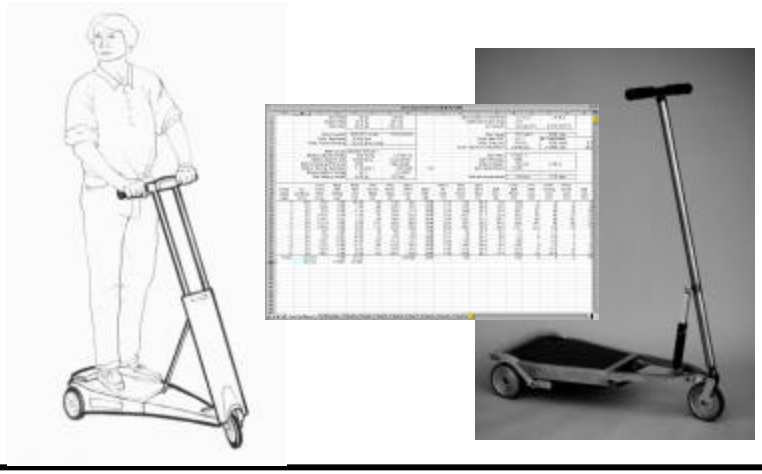
Scenario

Barriers addressed

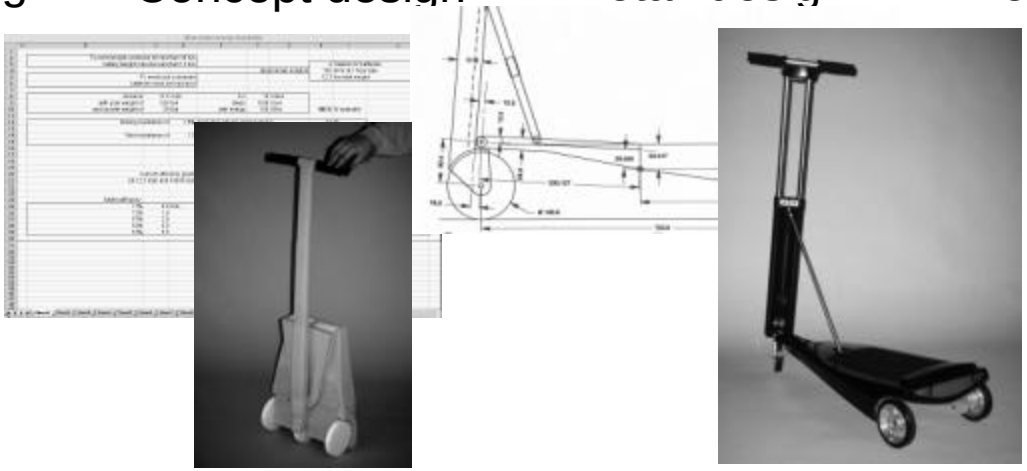
Applications

# Product Design

## Modeling context

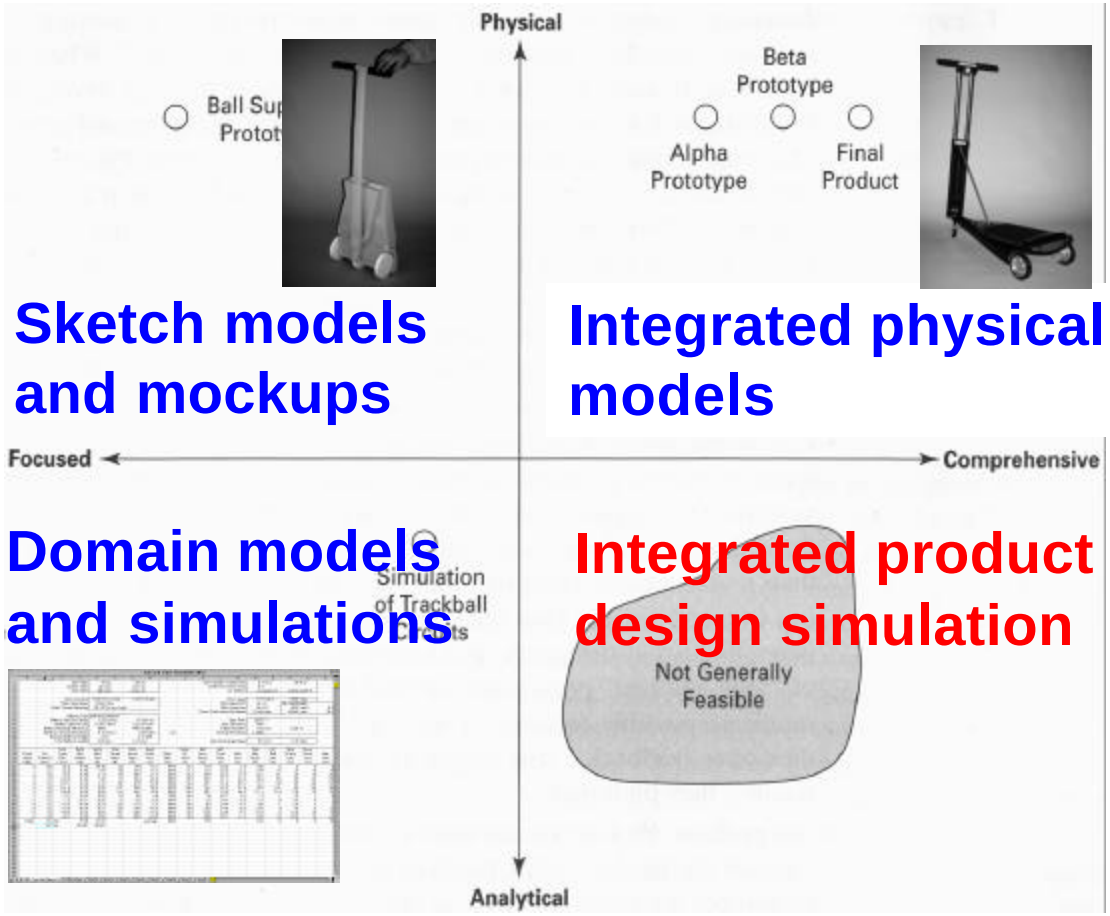


Planning Concept design Detail design Testing Ramp up



# Design Modeling

## Techniques




*From:* Ulrich and Eppinger,Product design and development, 2000

# Need

## Integrated system modeling and simulation

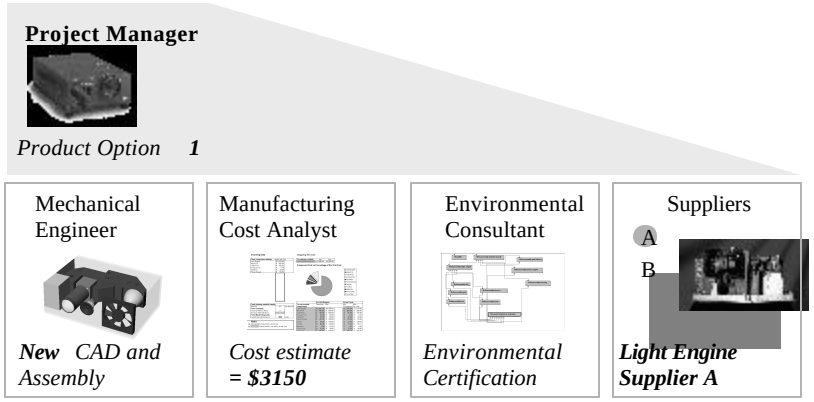
Mathematically predict and analyze the integrated behavior of products throughout the pre-prototype design cycle

# Benefits

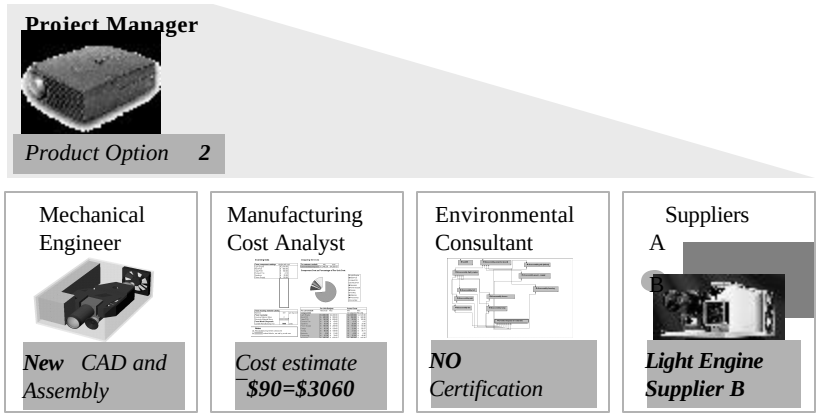
## Simulation-based integrated system analysis

Polaroid LCD projector

Seamless mathematical integration:
geometry, engineering,
life-cycle analysis,
customer and
intent-to-purchase simulations




Result:
integrated trade-off
cycle time reduced
from 3 months to
15 seconds




**“not generally feasible”**

# Hypothesis

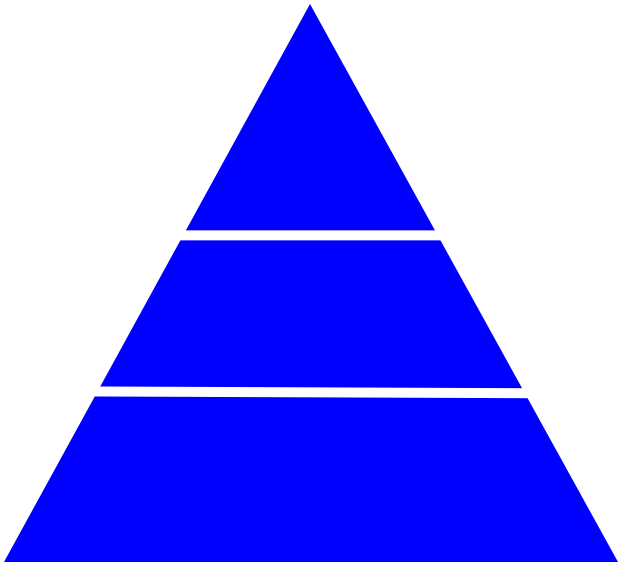
## Limitation is simulation synthesis, not analysis

Mathematical system modeling techniques do not match design synthesis needs

# Mismatch

## Traditional model integration methods

Explicit, fixed scope, command and control



Implicit, emergent

Existing methods do not accommodate flexible model growth, change, emergence, or rapid transitions between synthesis and analysis

# Synthesis Mismatch

## Consequences

Infeasible because of design ...

complexity, scale, rate of change

heterogeneity

proprietary knowledge

Cutkosky, 1996

# DOME

## Research goal

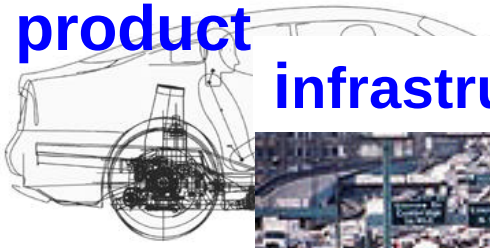
A new infrastructure for building the integrated simulations needed in design analysis

Fundamentally resolve traditional integration barriers

# Future Design

## Engineering emergent systems

**product**

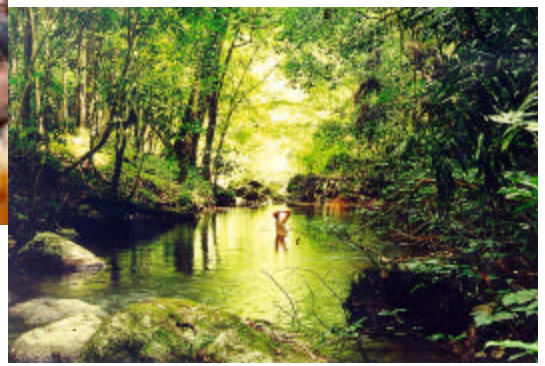


**infrastructure**

**urban environment**

**society**

**sustainability**



# DOME Inspiration

## Hypertext (WWW)

Revolution in infrastructure for building information networks—breaking control barriers

Any individual can add content

Any individual can access remote material and create local links to relevant materials

Result: an emergent network of information services

# DOME Concept

## World-wide Simulation Web

Any individual can make interfaces to focused simulations operable over the Internet

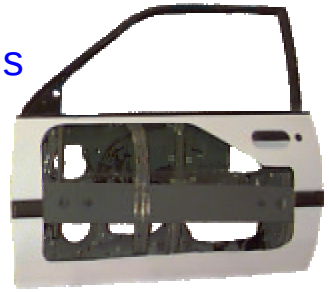
Any individual can access remote interfaces and create local mathematical links or bridge models between simulation elements

Result: an emergent network of parametrically coordinated simulations

# DOME Application

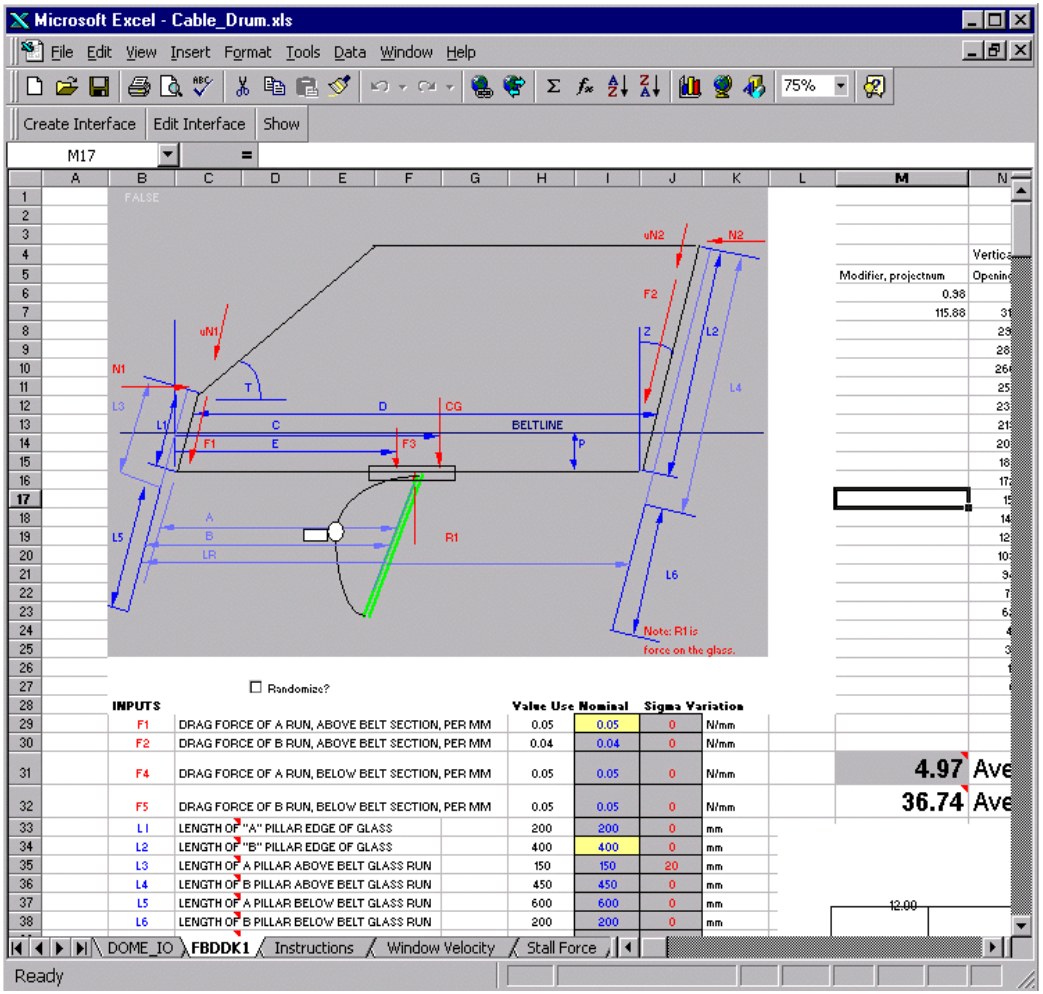
## Proof of concept field study

21 external simulations
3000 parameters



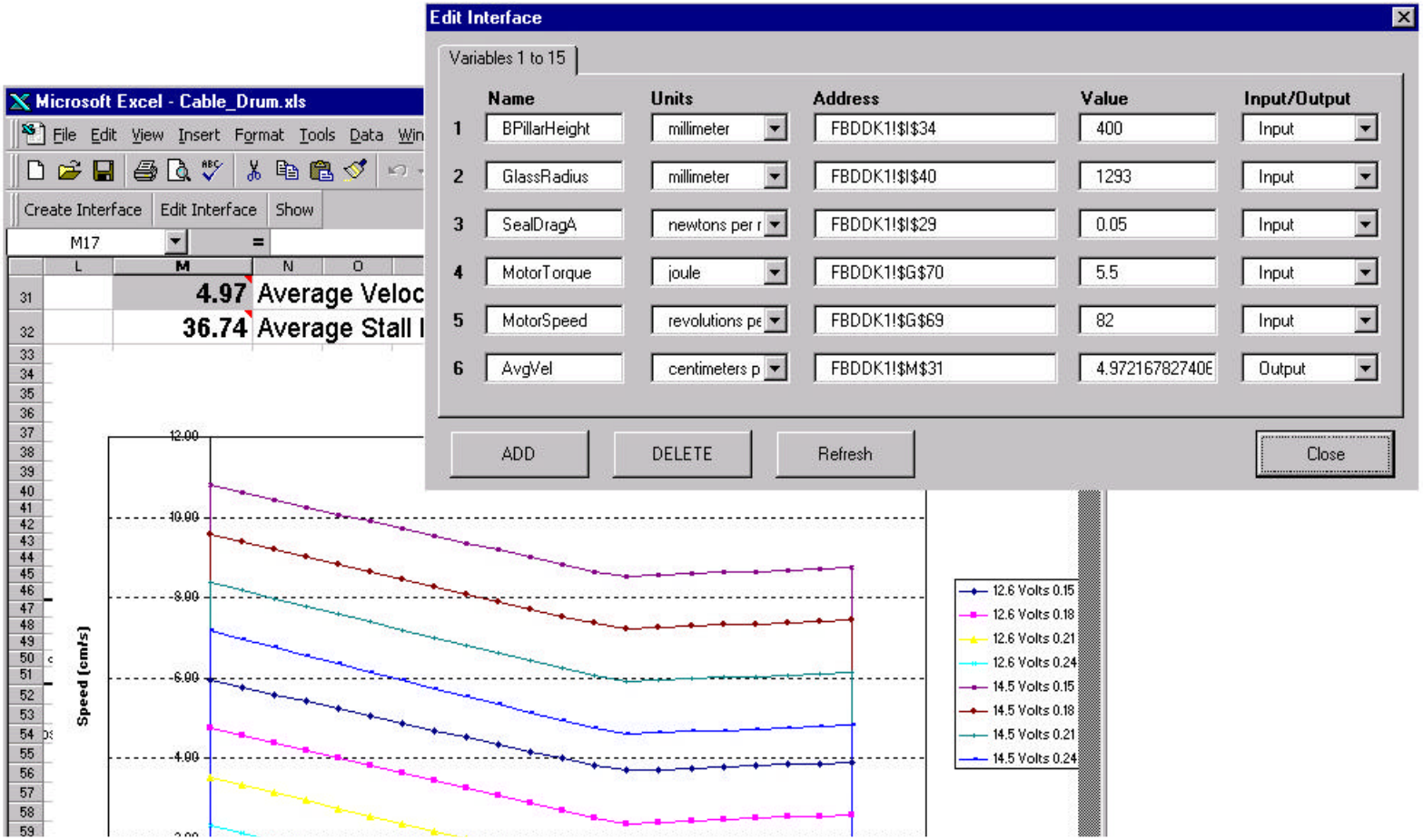
# Integrated Simulation Synthesis

## Participants build models using tools appropriate for their discipline



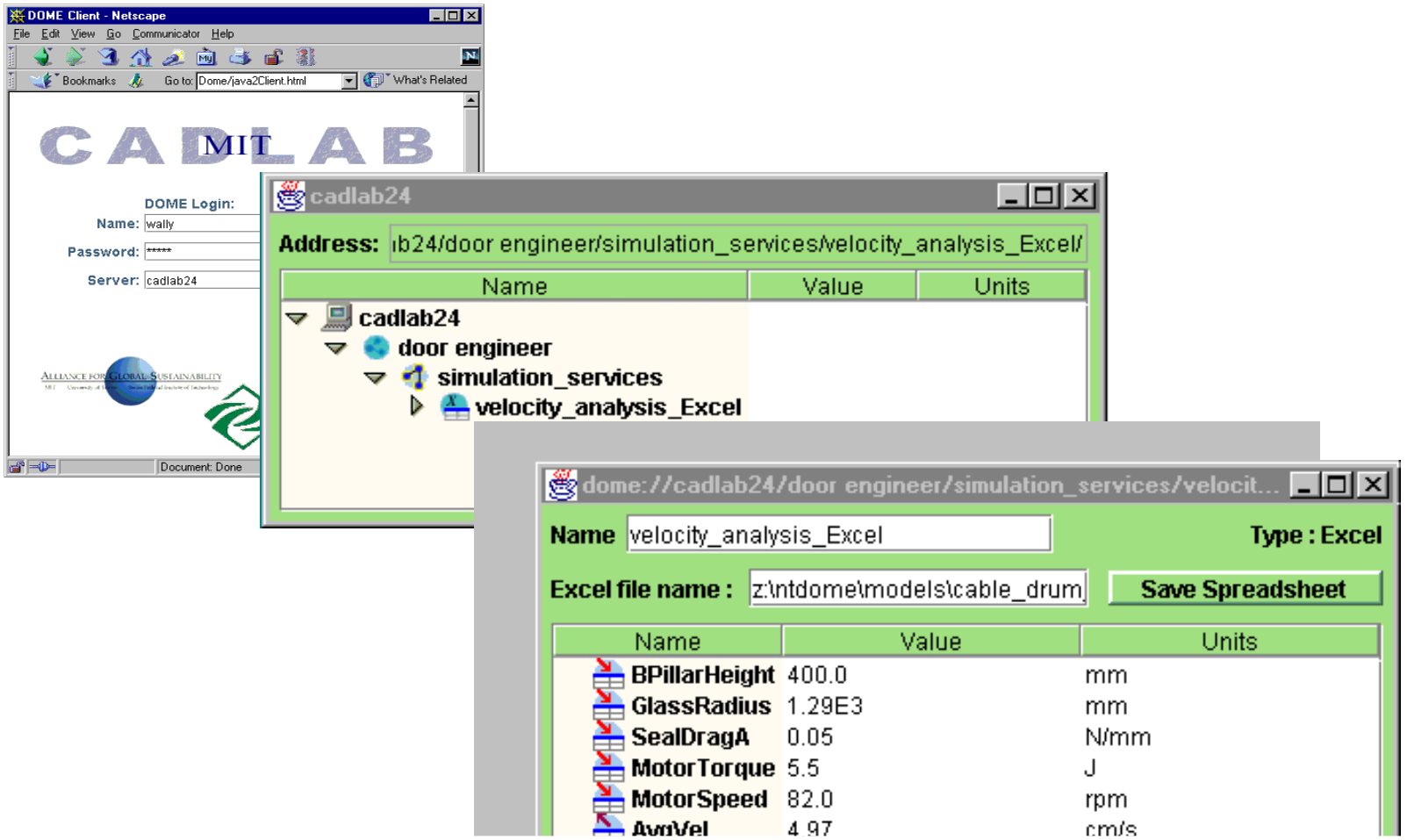
# Integrated Simulation Synthesis

## Participants define parametric interfaces to their focused simulations



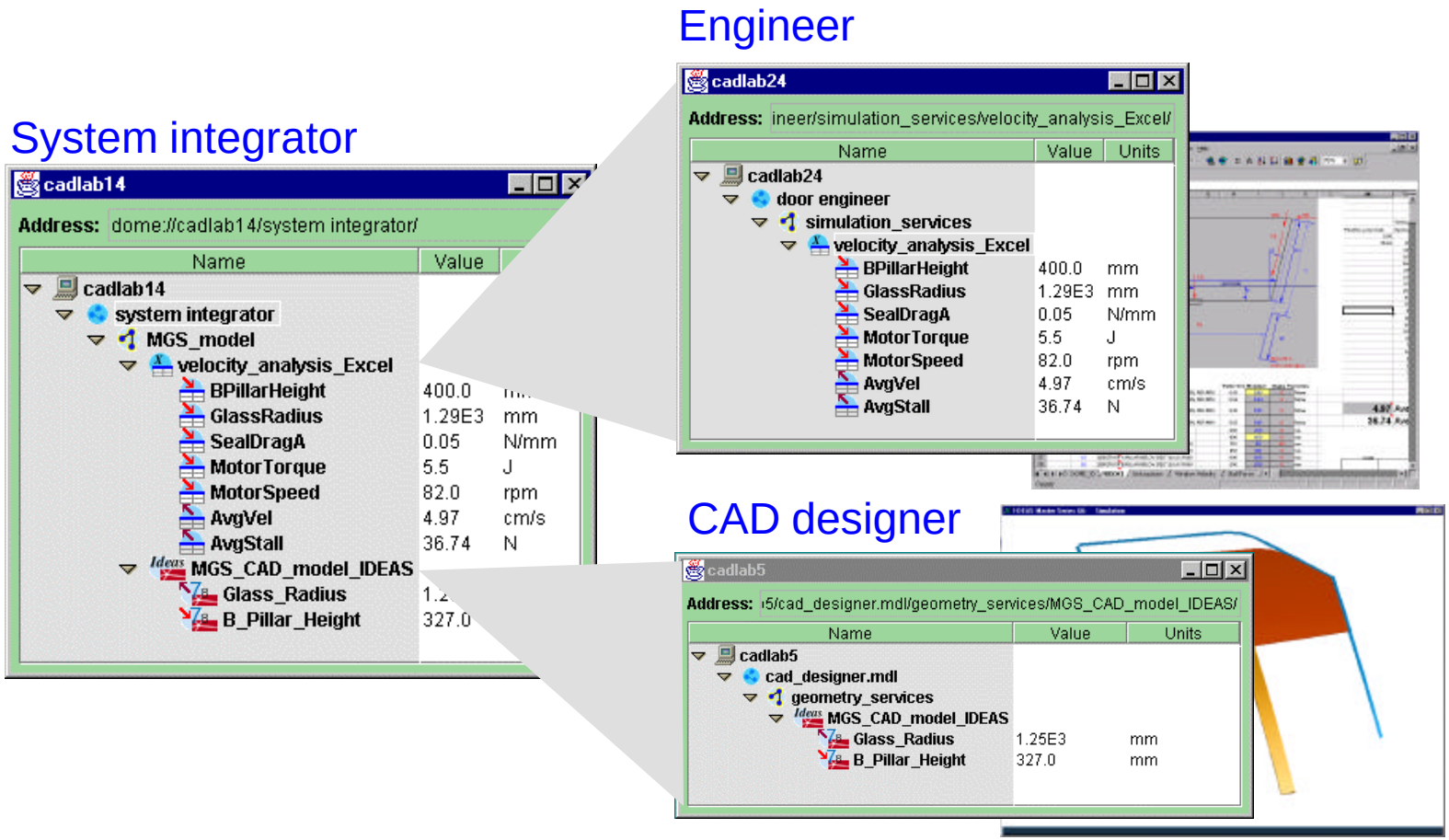
# Integrated Simulation Synthesis

## Participants deploy interfaces on Internet-accessible DOME servers



# Integrated Simulation Synthesis

## Participants create DOME bridge models between interface elements



# New Integration Infrastructure

## World-wide Simulation Web

Any individual can make interfaces to focused simulations operable over the Internet

Any individual can access remote interfaces and create local mathematical links or bridge models between simulation elements

A domain independent simulation infrastructure

# Integrated System *Analysis*

**Participants apply tools to elucidate tradeoffs, optimize designs, and understand system interactions**

Examples:

Decision theory (Kim and Wallace, 1999)

Genetic optimization (Gruininger, Senin and Wallace, 1996)

System structure analysis (Abrahamson and Wallace, 1999)

Model customization (Ferara and Wallace, in progress)

# Ford Application

## Results

Rapid system model development and evolution

(Integration process was 12 person days)

Interoperability of services between heterogeneous applications without sharing proprietary data models

Design tradeoff speed

(Ford engineer to supplier analyst: 10s *vs.* ~2 weeks)

Rapid design comparison of local design and supplier changes with global tradeoff viewpoint

# New Integration Infrastructure

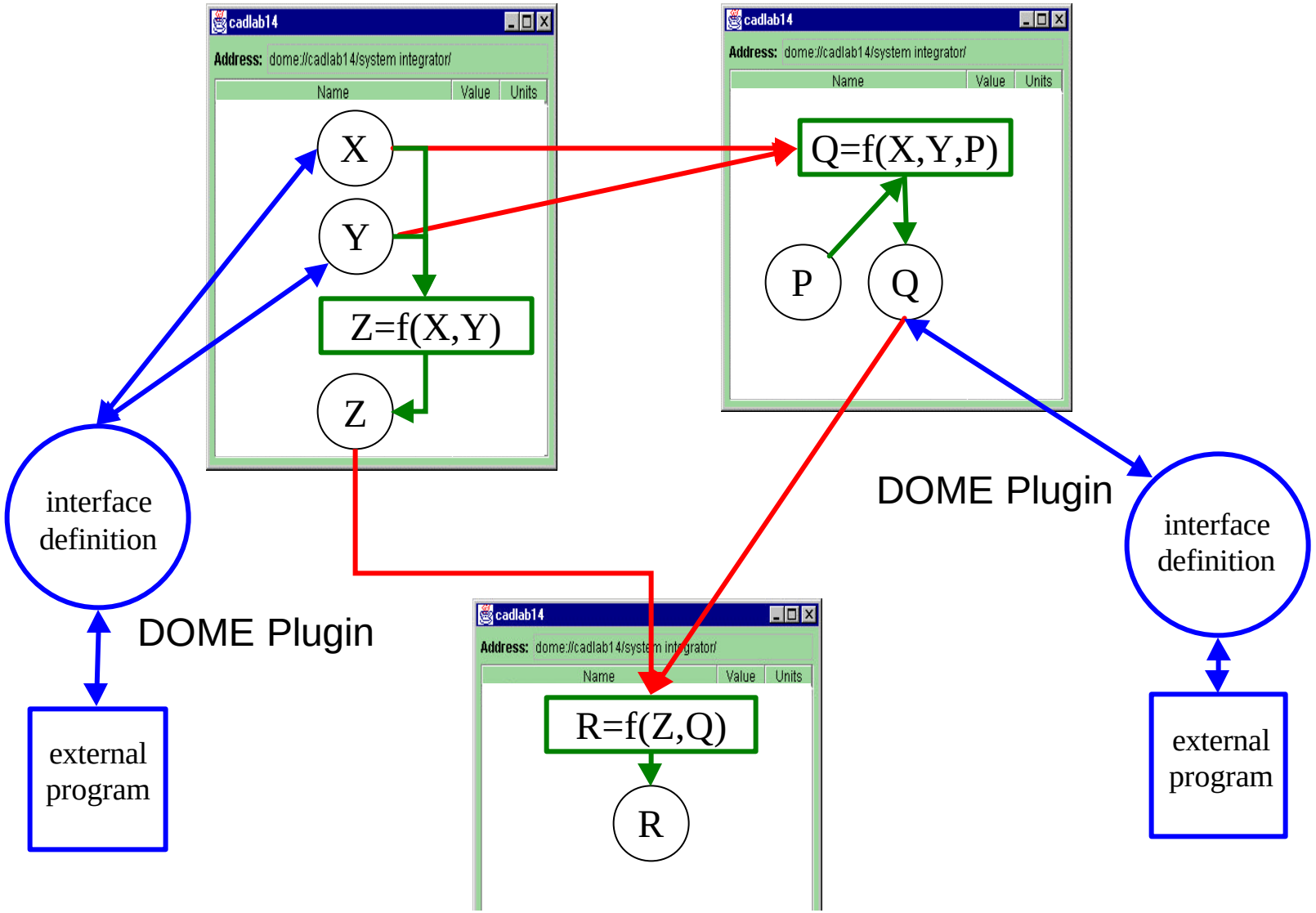
## Fundamentally resolve traditional integration barriers

Complexity, scale, rate of change

Emergent *vs.* explicit system definition

# New Integration Infrastructure

## Localized definition of interfaces and relationships

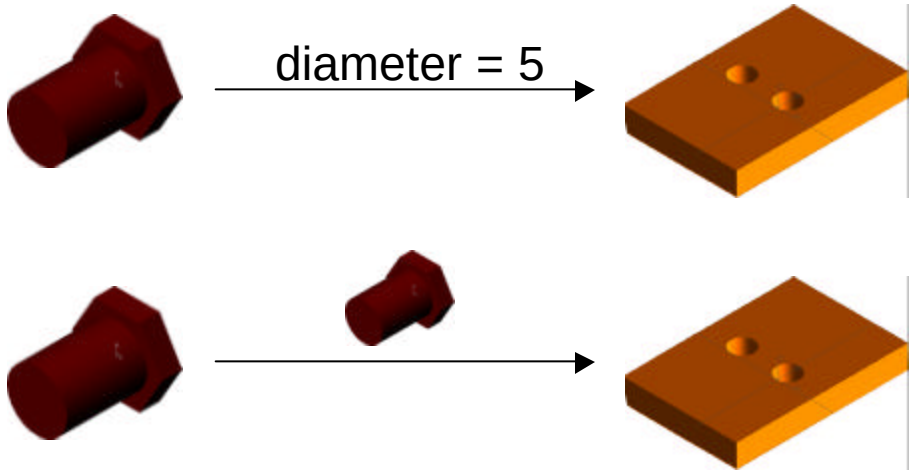


# New Integration Infrastructure

## Fundamentally resolve traditional integration barriers

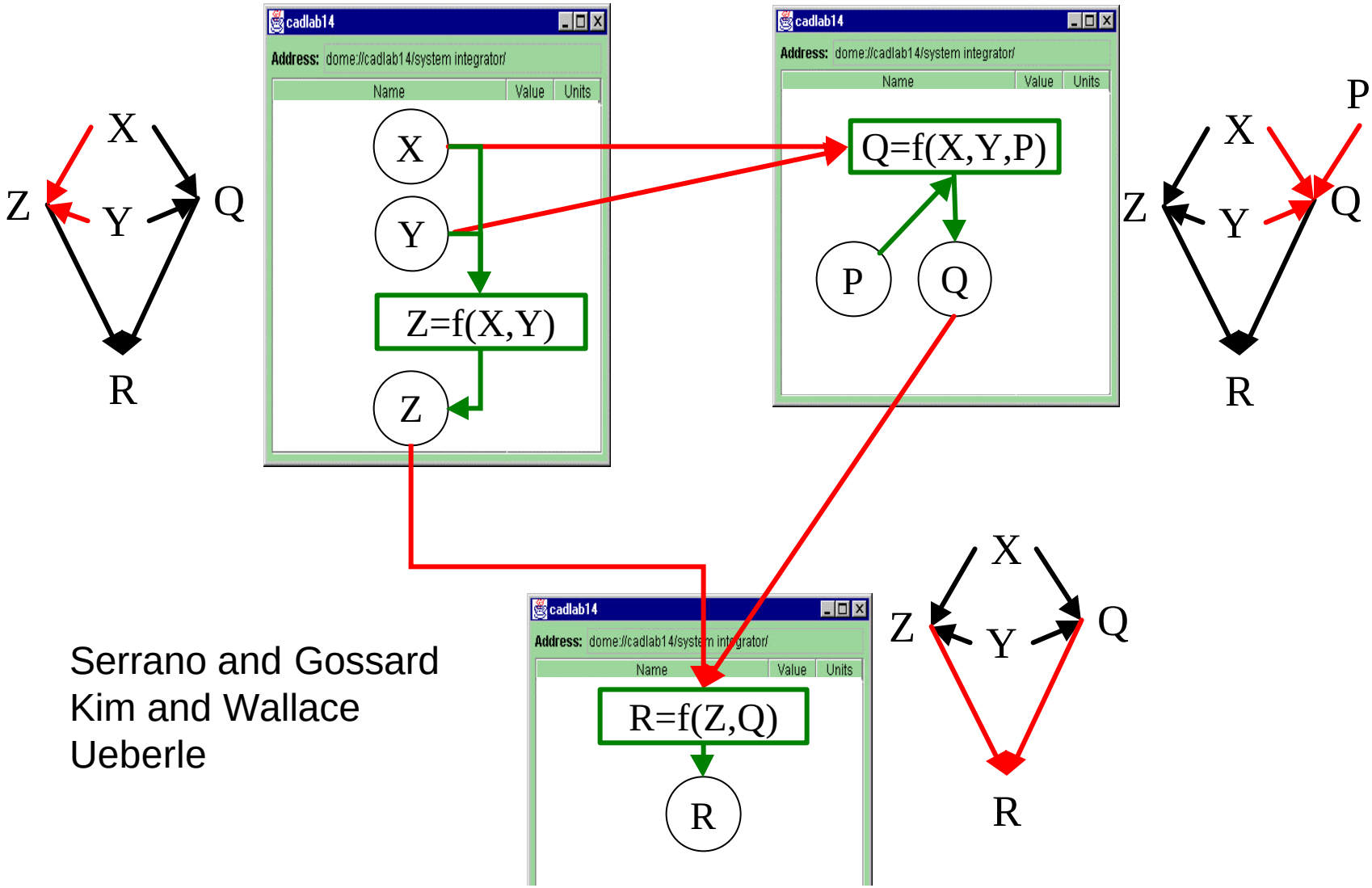
Heterogeneity, proprietary information

Parametric consistency *vs*. data model sharing



# New Integration Infrastructure

**Local solvers share causal mapping for externally accessible interface parameters**




Serrano and Gossard
Kim and Wallace
Ueberle

# Industry Pilot Applications

## Recently completed or ongoing

| Organization | Project |
|---|---|
| Ford | Door glass system<br>Integrated simulation across the design/supply chain |
| Ford | Fuel economy<br>Integrated technology assessment |
| Ford | Vehicle platform design<br>Parametric assemblies with multiple CAD systems |
| LG Electronics | Air conditioner design<br>Platform management |
| Boeing | New materials adoption<br>Integrated simulation across length scales |
| US Navy | Aircraft carrier ordinance delivery<br>Life-cycle cost reduction |

# Vehicle Platform Application

## Geometric assemblies

Traditional integration approach:

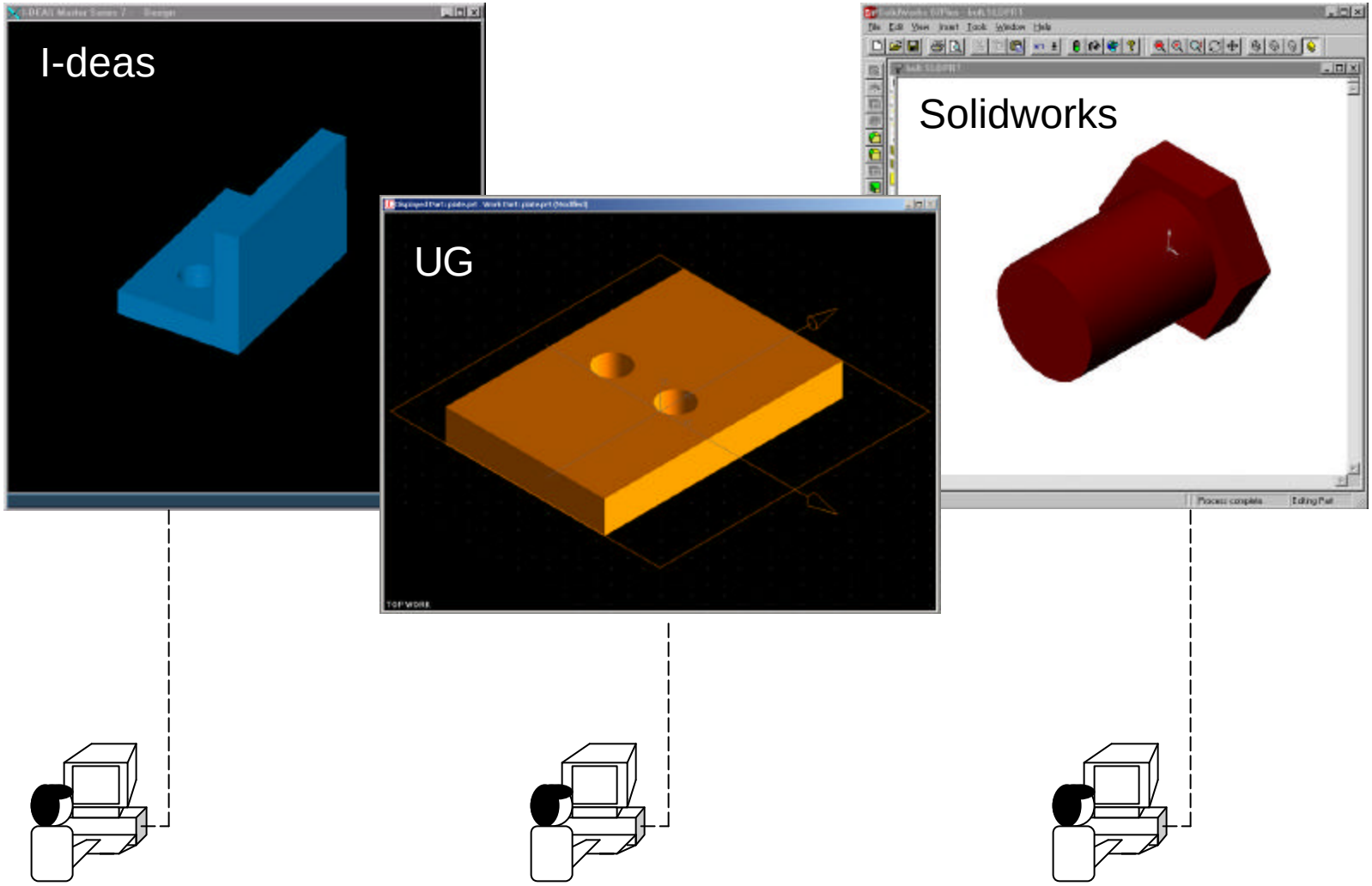
Each company has an official CAD system

All suppliers must use the official CAD system

Suppliers must provide native part geometry to automotive company

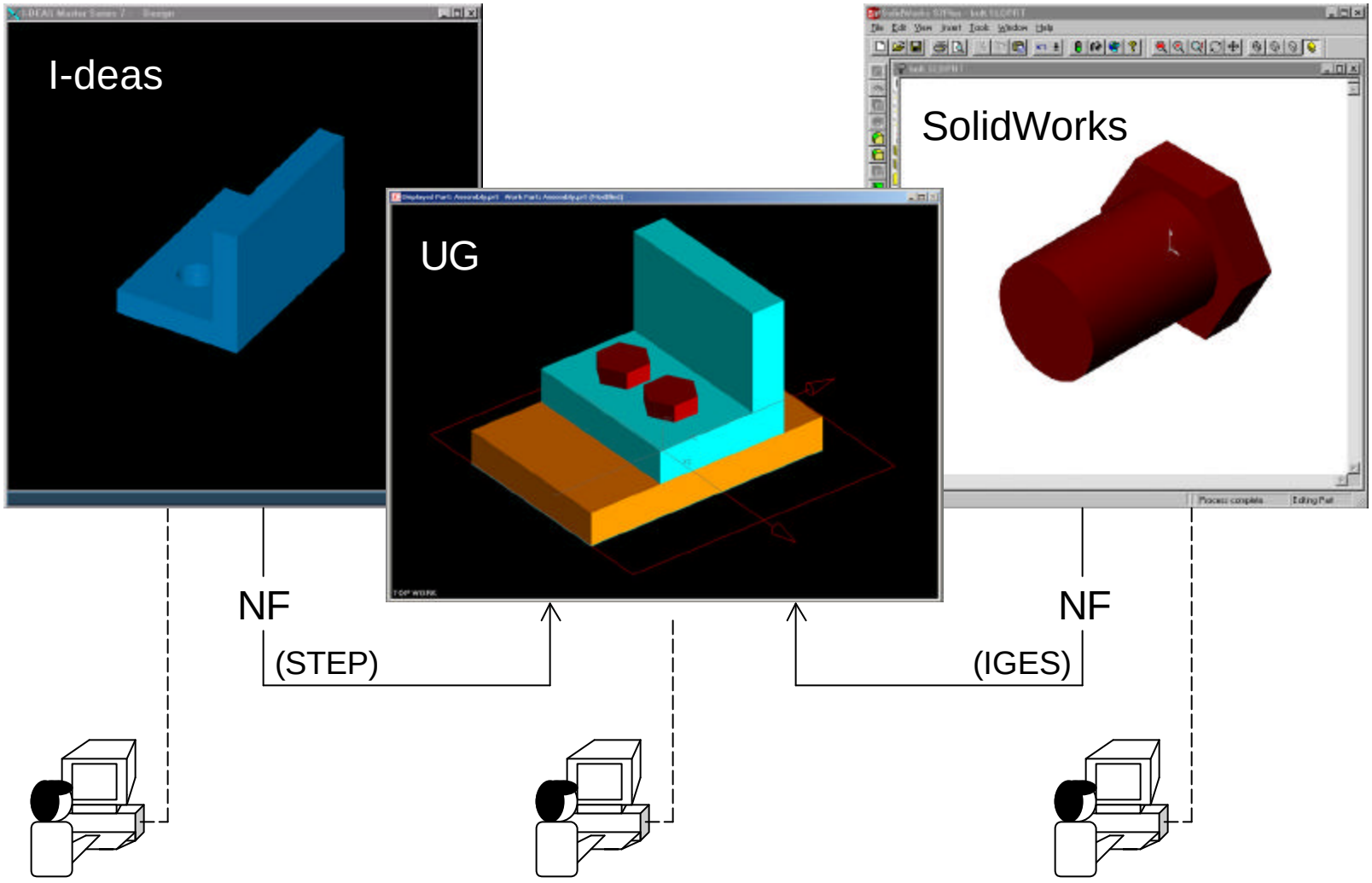
# Vehicle Platform Application

## Parametrically editable assemblies



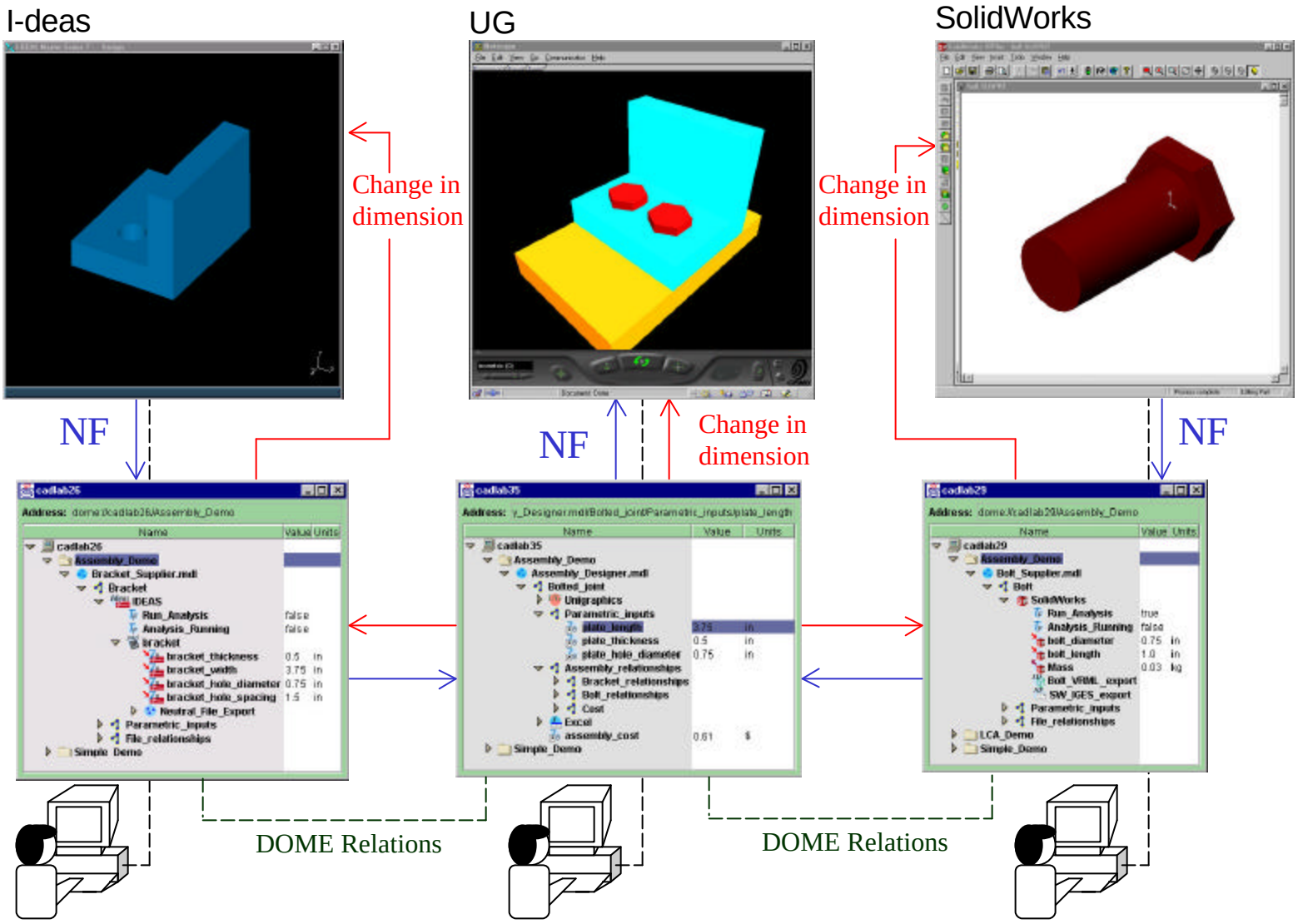
# Vehicle Platform Application

## Parametrically editable assemblies



# Vehicle Platform Application

## Parametrically editable assemblies



# Application

## Manufacturing object module: MOM